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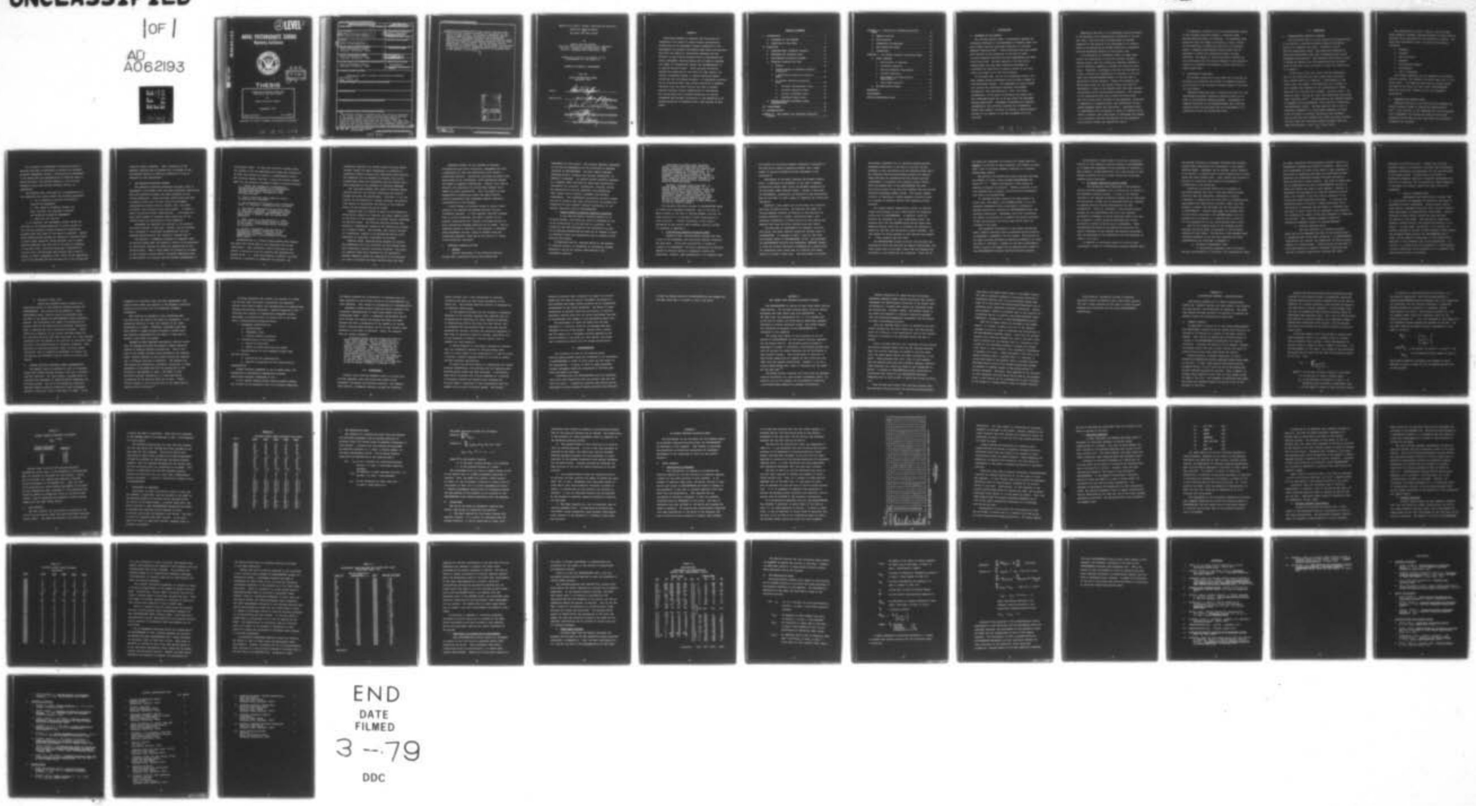

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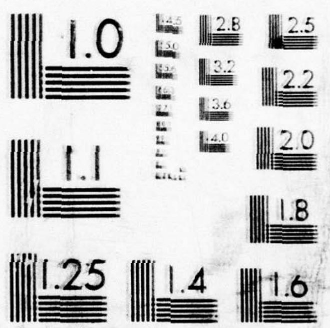

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THESIS

WORKFORCE PLANNING MODELS FOR
THE NAVAL AIR TEST CENTER

by

Robert Stratton Buffum

September 1978

Thesis Advisor: G.G. Brown

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Continuing pressure to maximize the utilization of resources at all levels in public sector organizations invites the use of management science techniques in the development of strategic and medium range plans and policies. When both the number of constrained resources and the projects to which those resources must be distributed are large, management decision-making can be aided by reducing the number of alternatives OVER

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through the implementation of an optimal decision model. Three resource allocation methods are presented for the Naval Air Test Center: the present incremental method; a capital budgeting method allocating one constrained resource in a satisfying solution; and an allocation method that allows conversion of manpower resources from one labor function and type to another through training, hiring, substitution or contracting. The latter model also includes constraints on capital investment and aircraft utilization in the selection of an optimum portfolio of projects over a time horizon of four years.

Workforce Planning Models
for
The Naval Air Test Center

by

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requirements for the degree of

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ABSTRACT

Continuing pressure to maximize the utilization of resources at all levels in public sector ogranizations invites the use of management science techniques in the development of strategic and medium range plans and policies. When both the number of constrained resources and the projects to which those resources must be distributed are large, management decision-making can be aided by reducing the number of alternatives through the implementation of an optimal decision model. Three resource allocation methods are presented for the Naval Air Test Center; the present incremental method; a capital budgeting method allocating one constrained resource in a satisfying solution; and an allocation model that allows conversion of manpower resources from one labor function and type to another through training, hiring, substitution of contracting. The latter model also includes constraints on capital investment and aircraft utilization in the selection of an optimum portfolio of projects over a time horizon of four years.

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I. INTRODUCTION

A. STATEMENT OF THE PROBLEM

For the past several years, congressional demands for increased efficiency in the Department of Defense (DOD) have been evident from the continued reductions in civilian manpower authorizations[1]. These reductions have been passed down through the DOD hierarchy in the form of lower civilian personnel ceilings for many headquarters and their field activities. Military manning in the Navy shore establishment has also been reduced by decreases in allowances and reductions in manning levels as the fleet units are brought up to 100% of allowance.

At the same time, and for the foreseeable future, the Navy weapons system procurement plans include a number of high-technology systems. The management of these systems will require new techniques throughout development, engineering, Test and Evaluation, (T&E), and fleet introduction, if the goals of providing the users with a well developed system are to be met within the decreased manning constraints. Management strategies for planning, implementing, and reviewing projects will necessarily become more complex, but must not become a labor-intensive process if all aspects of the Navy programs are to be serviced.

Especially important in the management planning process is the matching of an organization's workforce to the project load. This goal may be accomplished by optimum selection of the projects to be performed by an existing staff or by developing an optimum workforce to accomplish the most beneficial portion of the project load.

It is difficult to accomplish either of these goals within the constraints of civilian ceilings, military manning levels, and the limitations sometimes imposed on use of contractor manpower to accomplish certain project tasks. Therefore, a strategic plan must be developed for hiring, training and transfering of personnel to the projects that provide maximum benefit to the Navy and in particular to Naval Aviation. Within the strategic plan, short-range plans for the current fiscal year must be considered in light of the onboard staff and known internal and external social and political pressures. The strategy of the organization must also include mid-range plans that will allow timely training of new personnel, retraining or separation of existing staff, and distribution of projected manpower assets and constraints. Long-term trends in requirements must be defined in terms of functions to be added or deleted, new technologies in techniques and systems to be evaluated, and the time phasing for the systems as they progress through the acquisition cycle.

To adequately integrate all of the quantifiable factors in the strategic planning process, a computer-aided, decision-making process is indicated. To accomplish these objectives when the number of projects is large ($n > 800$) and the workforce is defined by more than 30 functional areas, a computer-aided decision making model must be developed to handle the interactions among the many variables. The impact of various strategic alternatives can be evaluated and the results compared in the context of internal and external environmental factors that are not easily quantified.

B. OBJECTIVES OF THE STUDY

The primary objective of this study was to provide the rationale for improving the process of workforce planning and its place in the strategic planning system of the Naval Air Test Center.

Secondary objectives were to develop the basis for both satisficing and optimal resource allocation models to be used in the workforce planning process. Development of computer solutions of the proposed models was a tertiary objective which was partially met with development of an algorithm to solve the satisficing model.

II. DISCUSSION

A. ORGANIZATIONAL STRATEGIC PLANNING

One of the key factors in the success of any organization is its ability to perform strategic planning and develop policies to implement the plans. Following a set of definite guidelines,a formal, long-range plan supported by short-and medium-range plans must be developed with active management participation. The strategic plan should be based on extensive research into the expectations and strategic plans of the rest of the hierarchy of which the organization is a subset.[2]

In the case of DOD, each level from the secretaries down to the field activity cost centers has a strategic plan, either explicit of implicit. Unfortunately in the latter case, the formal, long-range plan is an attempt to pull together the fragments of the organization's formal plans and fill the gaps with informal, intuitive plans. The explicit plans, such as the "Navy T&E Consolidated Long-range Plan" (February 1978)[3] are developed by the combined efforts of managers at the headquarter, field activity, directorate, and subordinate levels. The data base for such a plan is budgetary information for short-range purposes; mid-range plans are based on planning information from documents such as the Five-Year Defense Plan (FYDP) the Naval Aviation Plan and other DOD long-range program documents form the basis for planning in the 5 to 20 year future.

The combinations of short-, medium-, and long-range plans becomes a strategic planning document on which explicit policies can be developed for the allocation of assets. The asset base considered in Ref. 2 included the following variables:

1. Landspace
2. Airspace
3. Test facilities
4. Manpower
5. Aircraft/ship support
6. Encroachment
7. Cost of ownership

This thesis addresses only the manpower and workforce planning process, with emphasis on medium range (two to five years) plans. The study was specifically oriented toward the needs of the Naval Air Test Center (NAVAIRTESTCEN), where the author was a member of the line management organization.

B. WORKFORCE AND STAFFING PLANS

Workforce planning is the planning of the numbers and kinds of workers needed to perform the organization's work.[4] This function is the responsibility of the organization's management and relates the types of skills and knowledge and how many of each type worker are required to accomplish the workload.

As an adjunct to management's workforce planning, a staffing plan must be developed to perform the necessary personnel management actions. Participation by management in the definition and implementation of staffing plans is mostly advisory, with primary emphasis in the Civilian Personnel Office and Military Personnel Office, as appropriate.

The staffing plan, developed as an implementation of the workforce plan, should answer the following questions:

1. Is it feasible to provide the workforce required by management?
2. What types of personnel actions, how many, and when, are required to achieve the workforce planned by management?
3. What will the cost be?

It is important that management clearly define the workforce in the medium-range plan to allow training of new civilian personnel through cooperative educational programs that take three to five years to complete. Shorter range staffing plans provide for training of existing staff in their normal technical career patterns, and in upward mobility positions that take one to two years to complete. In the short term, recruiting plans that concentrate on critical skill and knowledge deficiencies take a year or longer to effect, depending on the timing of the identification of the shortage and the availability of new college and

technical school graduates. Thus, allocation of the manpower resource must be planned well in advance of the anticipated workload if effective staffing is to be an objective of the organization.

C. THE RESOURCE ALLOCATION PROCESS

The problem of resource allocation has been a part of management's environment since man began exchanging commodities that were desired by others, but were available in only limited quantities. Those decisions (which could have been as simple as what crop to grow, given an environment constrained by factors such as climate, soil, and labor available) have certainly grown more complex. In today's public and private sector organizations, the budget of a much larger number of different asset types must be considered within the constraints of each commodity.

Management can approach the solution to the resource allocation problem in many ways. However, the two extremes are a strategy of "disjointed incrementalism" and the approach associated with the "rational, economic man."[5]

The disjoint, incremental approach is frequently used by decision makers when the number of factors to be considered in the decision exceeds the cognitive capabilities of the decision maker. When a large number of projects is included in the universe to which several unrelated commodities must be distributed, the analysis quickly becomes overwhelming to

the decision maker. He then must bound the problem within the context of his own experience and reduce the information on which the decision is based to a comprehensible level. The following summary from Ref. 5 given the primary requirements for the disjoint incremental method of decision making.

> 1. "Rather than attempting a comprehensive survey and and evaluation of all alternatives, the decision-maker focuses only on those policies which differ incrementally from existing policies.
>
> 2. Only a relatively small number of policy alternatives are considered.
>
> 3. For each policy alternative, only a restricted number of 'important' consequences are evaluated.
>
> 4. The problem confronting the decision maker is continually redefined: Incrementalism allows for countless ends-means and means-ends adjustments which, in effect, make the problem more manageable.
>
> 5. Thus, there is no one decision or 'right' solution but a 'never-ending series of attacks' on the issues at hand through serial analyses and evaluation.
>
> 6. As such, incremental decision making is described as remedial, geared more to the allieviation of present, concrete social imperfections than to the promotion of future social goals."

Incrementalism is a decision making method that adjusts the status quo toward some of the perceived goals of the organization. When considering capital budgeting in the context of selecting a set of projects that maximizes net present value or some other measure of benefit, and then developing a workforce to accomplish the projects, the

incremental approach will seldom achieve the best result. Instead, except for small adjustments in workforce to accomplish certain projects with identified large benefits, the workforce will be assigned to projects that can be accomplished within the constraints and will assure that a high percentage of the workforce is gainfully employed.

The "rational, economic man" model of decision making requires that all the factors influencing the decision process are known and quantifiable. Obviously, if all the factors can be defined for a complex problem, the problem then remains of quantifying the factors so the relative merits of the alternatives may be ranked.

Assuming that all aspects relevant to the analysis of alternatives leading to a decision are known, keeping track of the effect of one parameter on another quickly overwhelms the decision maker. The rational decision process thus requires a "bookkeeping" system so the analysis can proceed in an orderly manner. This process, when carried through to a conclusion, results in an optimum decision on which allocation of resources to projects can be based.

Computer-aided, decision-making systems can perform the bookkeeping and logic functions for the manager faced with large-scale resource allocation problems. The powerful computer-aided tools developed by the operations research community reduce the complexity of the decisions to a level with which the human decision maker can cope.

Somewhere between the two extremes of disjoint incrementalism and total rationality, management may find a combination of logic and subjectivity that yields a satisficing solution. Satisficing solutions are better than those based on raw information, since aggregation reduces the number of apparent alternatives. However, this type of solution will generally not provide deep insight into a number of viable alternatives. Also, the impact of some unquantified variables may render the model solution totally unacceptable when management applies subjective considerations to the analysis.

A third concept in decision making is called "mixed scanning" and combines the optimum solution with the incremental approach. In this approach, Etzioni[5] proposes that in crisis situations, the need to search for all possible alternatives will require an optimum solution on which significant strategy decisions can be based. When no immediate threat is involved in the decision, a concensus among management can most likely be reached using the incremental approach, which may be the result of a satisficing analytical technique.

D. WORKFORCE PLANNING FOR NATC

1. General

Several approaches to the workforce planning process were investigated during the research and

development of this thesis. The simplest approach considered is the one now implemented for the allocation of manpower resources at NAVAIRTESTCEN. The most complex approach considers project variables and resource constraints, in addition to manpower. An optimal project portfolio selected by a computer model provides for labor-type substituting (contractor for civilian), transfering, training, hiring, and separating of civilian personnel, and considering other assets such as capital investment and aircraft requirements. The intermediate satisficing solution selects the set of projects that best utilizes only the present and predicted civilian manpower resource distribution to the several functional areas at NAVAIRTESTCEN.

2. <u>Present Method of Manpower Resource Allocation</u>

In any decision-making technique applied to an on-going process, the status quo must be considered as one of the alternatives to the solution of a problem. The status quo has been developed by the organization as part of its planning methodology and need not be changed if there is concensus within the organization and no external threat from the environment.

As described earlier, decision making in the absence of internal conflict is frequently an incremental process. Reference 5 points out several shortcomings of the incremental approach:

> "Decisions by consent among partisans within a socity-wide regulatory center and guiding institution should not be viewed as the preferred approach to decision-making. In the first place decisions so reached would, of necessity, reflect the interests of the most powerful, since partisans invariably differ in their respective power position; demands of the underpriveleged and politically unorganized would be underrepresented.
>
> Secondly, incrementalism would tend to neglect <u>basic</u> societal innovations, as it focuses on the short run and seeks no more than limited variations on past policies. While an accumulation of small steps could lead to a significant change, there is nothing in this approach to guide the accumulation; the steps may be circular--leading back to where they started or dispersed--leading in many directions at once but leading nowhere."

The resource allocation process at NAVIARTESTCEN seems to follow this incremental approach, even in the face of major threats in the form of reduced manpower ceilings and high visibility T & E projects of great significance to naval aviation. A further discussion of the author's perception of the current NATC workforce planning process is contained in Appendix A.

3. A Satisficing Resource Allocation Model

Computer-aided, decision-making systems have been a part of the management and operations research literature for many years. Since each organization is unique as viewed by its management, the direct application of existing methods of decision making is frequently viewed with skepticism. However, when implemented in its simplest form,

the problem of allocating manpower resources to projects is the same as the capital budgeting problem, and a large number of solution methods have been published in the literature.[6]

Development of any model requires two primary factors. First, a commitment by management to the idea of seeking alternatives beyond those within the bounded rationality of the individual human decision makers. Second, a data base of requirements, constraints and benefits to the organization must be available to form a means of comparing the alternative strategies.

Hopefully, this thesis will be the basis for achieving the first of these factors. By examining the impact of various manpower resource allocations on the portfolio of projects selected by a simple, satisficing model, more judicious allocations of ceiling points to cost centers and improved long term and co-op training plans may result.

The data base of requirements for manpower, aircraft, facilities, and other resource categories already exists at NAVAIRTESTCEN. In response to Refs. 9 and 10, the Plans and Programs Office of NAVAIRTESTCEN (CT-85), has developed the NAVAIRTESTCEN Workload Plan Management (NATCWPM) system in which all project workload is estimated for a period from the immediately past fiscal year to a horizon five years beyond the current fiscal year. This data base is in place

and readily accessible for an improved planning process. Estimated constraints in the form of civilian ceiling assigned to each directorate are the workforce plans which the computer-aided decision-making process will develop. These need only be estimated from the current ceilings incremented in accordance with planning control totals, which are passed down to the NAVAIRTESTCEN and other activities as part of the Five Year Defense Plan and the DOD Planning Programming Budget System. The missing element critical to developing a simple manpower allocation model is a measure of benefits derived from completing direct projects.

As a public sector organization, profit or retained income from projects is not a valid motive for accepting direct work at NAVAIRTESTCEN. In addition, since all projects are accepted on a cost reimbursable basis, the planning data from the NATCWPM system should assure that adequate planning lead time is available for sponsors to budget for the Test and Evaluation of their programs. The real benefit of doing projects is that derived from support of naval aviation and the fleet.

The NAVAIRTESTCEN project priority list has been the reference by which the services of support directorates, and other assets such as aircraft, range time and airspace are allocated in the competition for resources. Since one of

the bases for assignment of priority has always been the benefit of a project to Naval aviation, the concept of using such a list to allocate manpower resources in a planning system seems logical.

The priority of projects has within the past year been the subject of closer liason between NAVAIRTESTCEN and AIR-06 [12, 13]. adding confirmation to the concept of resource allocation by priority. However, priority is now only assigned when a project is active and has milestones that need to be accomplished.

If estimated project priority for each project, by fiscal year, was added to the NATCWPM system, all of the necessary parameters would be available to achieve an optimum selection of projects for NAVAIRTESTCEN within the workforce constraints. Management could then investigate the effect of reallocation to improve the project portfolio to meet the political and social goals which cannot be included in the model.

The conceptual development of the simple satisficing model, based on benefits from an estimated project priority is presented in Appendix B of this thesis. The solution of the model has been provided by Associate Professor G.G. Brown and Major C. Mavrikas, a student at the Naval Postgraduate School, proving the feasibility of applying such a model to the NAVAIRTESTCEN strategic workforce planning process.

By developing a simple model to provide a satisficing solution to the workforce planning process in NAVAIRTESTCEN, it is hoped that management can be persuaded to implement a more rigorous, closed system that will yield optimal or near optimal solutions to aid in future medium and long-range planning policy decisions.

4. An Optimal Resource Allocation Model

The satisficing model described in the preceding section provides management with a limited tool to assist in the workforce planning process. If more of the factors involved in the resource allocation process can be identified and quantified, a model can be developed which will approach an optimum solution through consideration of other alternatives. Since all variables in the decision making-process are not quantifiable and due to the (natural) resistance of managers to having decisions thrust upon them by a computer, a model should be developed that leaves alternative courses of action open to management. These alternatives are based on the qualitative political and social influences of the internal and external environment that are perceived by the organization and the hierarchy of which it is a part.

In addition to the direct effect of civilian labor constraints in each of 35 functional area/cost centers (FACC),

the optimal allocation of manpower resources must consider several other constraints and alternatives to the present staffing design. Employees can be trained, either formally or on-the-job, to perform useful direct project work in areas other than their present FACC. Also, shifts from civilian to military or contractor labor should be considered as alternatives to the status quo.

Selection of projects based only on available or projected manpower may yield a less than optimal project portfolio when the additional constraints of capital investment in laboratories and facilities is considered also. Improvements and Modernization Projects (IMPs) have been planned to improve the efficiency of test and evaluation at NAVAIRTESTCEN. Without these IMPs, the planned level of work effort contained in the NATCWPM master file will necessarily be increased, or a reduced level of testing will be necessary due to the inefficiencies which result.

Each of the resource costs of the proposed optimal resource allocation model is discussed in the following sections of this thesis. The details of the proposed model, including estimates of all the cost functions and their implementation are discussed in Appendix C.

a. Personnel Reassignment Costs

In reallocating resources, once an activity has been established as a functional line organization, there

are costs incurred by moving personnel between functions to accomplish a balanced and effective workforce. These costs can be expressed in terms of man years of labor expended in recruiting or separating personnel and inefficiencies when personnel are transferred between functions and must be given on-the-job or other training. The study of these costs for an organization the size of NAVAIRTESTCEN involves an effort far beyond the scope of this research. However, in developing the rationale for an improved workforce planning model, this element is the next logical expansion on the satisficing model described previously. In selecting the optimum portfolio of projects, reduced efficiency due to reallocation of personnel has the effect of increasing the man years of effort which must be assigned to the projects, not increasing the number of man years required to accomplishing the work. Thus, manpower assigned becomes the constrained commodity instead of required manpower.

b. Aircraft Operating Costs

The cost function of a workforce planning model can also be expanded over that of the previous model to encompass more of the asset categories. At NAVAIRTESTCEN, laboratories and aircraft are commodities for which projects compete on a regular basis. Limited assets are available in both areas because of capital investment limitations and aircraft inventory restrictions (although the latter

constraint is relatively soft). Flight hour yield per aircraft varies as a function of aircraft type, maintenance manpower availability and expertise, and the responsiveness of the supply system. Factors such as the effect of maintenance manpower expertise on manpower requirements are difficult to quantify, but the addition of these dimensions to the model will greatly improve the model utility for management.

c. Capital Investment Costs

Improvements and Modernization Projects (IMP) for laboratories and equipment are planned on the basis of estimated workload requirements. These projects require large capital investments each year from a limited institutional Improvement and Modernization (I&M) budget. Project selection criteria should include the costs and best utilization of this asset. Each IMP has an acquisition schedule, funding profile, and identified projects it will support. In many cases, the ability to do a project is directly affected by the IMP or IMP's related to that project. The estimated funding profile for NAVAIRTESTCEN I&M is known, and the impact of variations in this constraint is important to the workforce plan of the organization. If certain I & M projects are not completed in a timely manner, critical testing may not be possible on T & E programs, and thus workforce plans are affected.

d. Contractor Labor Costs

Income from projects does not seem to be a significant factor in the workforce planning process for NAVAIRTESTCEN. The projects are performed on a cost-reimbursable basis, usually within the estimated costs provided to the sponsor by NAVAIRTESTCEN project personnel. However, the unestimated cost impact of reallocation of project staff by the model must be considered, especially when it requires the use of contractor personnel. These costs are in addition to the project estimates submitted for the Field Activity Plan (FAP) data base, so a cost increase constraint must be imposed on the addition of contractor labor and due to the inefficiencies of personnel transfers. Thus, decisions on workforce personnel types (civilian versus contractor) must be tempered by management to account for the external environmental factors related to project cost impacts.

E. FACTORS AFFECTING SUCCESSFUL MODEL IMPLEMENTATION

The manager cannot be expected to rely on a decision system that always produces solutions that are in conflict with his intuition. For this reason, a process which is understood by management is required before commencing the decision process. The use of the system as a heuristic approach toward alternative generation lets the manager develop a feeling of trust if the model is "good". If an

incomplete or inaccurate model has been implemented, with results which always are opposite to the manager's intuition, distrust of the system will be reinforced, probably irreparably.

This distrust by managers is also reinforced when incorrect data are used as the basis for processing. It is frequently difficult to test the validity of all input information to a model. Therefore, management must make every effort to supply accurate forecasts, current data, and realistic constraints for the model, if they want to achieve a high level of success.

Perhaps the most important man/machine conflict occurs when the manager perceives the system as making decisions instead of offering feasible alternatives. Even in the case if the optimal solution being produced by the computer model, factors external to the logical process may indicate that a different solution is desirable. The manager must then modify the constraints, variables, objectives, or other parameters in the model and test the sensitivity of the solution to the changes in input. The model is only providing relevant information in a form more easily interpreted by the decision maker and no more. "Basic decision making is still the province of the human mind in complex policy situations."[6]

Although management may concede the validity of a model, and the data base from which alternatives are generated, several other factors affect the implementation of sophisticated planning and decision techniques. Research reported in Ref. 7 indicates that success in implementing management science approaches to problem solving is closely tied to the three sets of characteristics summarized below.

1. Management characteristics
   a. Sophistication
   b. Management style
   c. Decision making orientation
2. Characteristics of the problem
   a. Nature of objectives
   b. Manner in which objectives are stated
3. Characteristics of the management science team and the solution
   a. Sensitivity and responsibility
   b. Realistic recognition of the difficulties of implementation

Without positive responses in all of these areas, the probability of successfully implementing advanced quantitative decision techniques is low.

In any complex computer-aided, decision-making system, the validity of the analytical tool is of primary importance.

The models proposed for reallocation of resources have not been subjected to the critical review of all NAVAIRTESTCEN top level managers. This review is a prerequisite to implementation.

Reference 8 makes several important points concerning the successful implementation of large scale models like this reassignment model. First, an adversary relationship should exist between the analyst who designs the model and those managers who have a perspective of the system as it exists. Second, computer-aided analysis can be of great benefit after concensus on the model is achieved. Third, the computer does not replace judgement.

> "Computers cannot replace analysts and decision makers since computers are not a substitute for clear, hard thinking. Just as analysis should be a servant of judgement, computers should be the servant of analysis. They are a substitute for tedious calculations. They save a great deal of time and, therefore, allow detailed exploration of more alternatives for a given problem or allow more problems to be solved. ...The point is to render unto computers the things that are computers' and to judgement the things that are judgement's. In the end, there is no question that analysis is but an aid to judgement and that, as in the case of God and Caesar, judgement is supreme." [13]

III. CONCLUSIONS

Without relief from the downward trend in civilian and military manpower, Navy activities must improve their management techniques for workforce planning. The commonly used disjoint, incremental decision process for workforce

design examines only a few alternatives to resourse allocation and does not make large adjustments to the status quo. This process generally results in concensus by the decision making group.

At the opposite extreme from the disjoint, incremental technique is the rational approach that requires that all alternatives be identified and their effects be examined. In organizations such as the Naval Air Test Center, with an estimated 900 plus projects over a seven year period, performed by civilian, military and contractor personnel in more than 30 functional area/cost centers, quantifying all of the variables to achieve a totally logical plan is probably not cost effective.

A "mixed scanning" or contingency approach to planning uses the incremental approach to decision making when there is little threat to the organization; in time of crisis, a rational, economic approach should be utilized to effect the best workforce distribution.

To assist the decision makers in implementing the "mixed scanning" methodology, the rationale for two computer-aided decision-making models has been developed. A satisficing model which allocates only civilian manpower as a function of projected workload and benefits will increase the decision maker's cognizance of more alternatives than the present ceiling point allocation system. The optimal

resource allocation model considers the impact of aircraft assets and the need for capital investment according to a time schedule and budget before projects can be successfully accomplished at the levels estimated. The effect of these constraints on projects which are politically or socially desirable (factors which are not easily quantified) may also be investigated with respect to the estimated project load.

The development of these two models has not been subjected to a critical review by the managers who must implement the use of the models. Without such a review, and the support for a management-science approach by the decision-makers at the Naval Air Test Center, the status quo in workforce planning will not change significantly.

IV. RECOMMENDATIONS

The rationale for each of the computer-aided decision-making models should be considered by the management of NAVAIRTESTCEN in light of their goals for the future of the organization. If merit is found in these processes, further refinement should be incorporated in the data upon which the models are based.

A workforce plan for NAVAIRTESTCEN should be developed which will most effectively meet the project load over the next four years. A supporting staffing plan should also be developed to assure properly trained personnel are available

to meet the demand placed on NAVAIRTESTCEN as new systems and aircraft reach the T & E phase in their life cycle.

APPENDIX A

THE CURRENT NATC RESOURCE ALLOCATION PROCESS

The NAVAIRTESTCEN is typical of many large public service organizations. For the past several years, civilian ceiling decreases have been passed down from NAVAIRSYCOM. At the same time, the requirements for T & E on systems such as the F/A-18, LAMPS, and AV-8B require additional manpower resources in several functional areas. The current method for allocation of manpower at the NAVAIRTESTCON is discussed in this Appendix.

Two groups that impact on the allocation of all resources at NAVAIRTESTCEN are the Project Priority Committee and the Budget Council. The project priority system is management's attempt to establish a relationship between more than 500 projects so scarce resources can be distributed in some agreed-to manner. This system seems to work well in short-range competition for support by test facilities and labor from the support directorates. However, it is not a long-or medium-range tool, since it reflects only the needs for the next year[13].

The Budget Council provides the actual plan for manpower resource allocation on a year-to-year incremental basis. An explicit plan is not evident, but the method is basically a zero-base budget approach to manpower distribution.

General guidelines for submitted the directorate/department manpower budget contain directions that certain management and administrative functions to the branch level be staffed at a minimum level before the functional areas are prioritized. Minimum, present, and optimum levels in all areas are budgeted in a series of decision packages that the directorate/department management then serializes in order of decreasing priority.

Only the "optimum effort level" is defined by the cost center workload for the next fiscal year, and the priority given to a function is not specifically tied to the relative priority of projects to be performed during the next 12 months.

Given a project priority list, year-end civilian ceiling, and project manpower demand from the FAP workload planning data, the project workloads are summed in priority order until the labor demand equals the labor availability in man years. Those projects that occur later in this sequence than the project using the last available manpower (positive slack resource) are listed for deferral and transmitted to AIR-06. A reclama on NAVAIRTESTCEN project priorities is coordinated from inputs by the NAVAIRSYSCOM Assistant Commanders and is used by NATC to modify the project priority list.

From the same data source (FAP workload planning data and year-end civilian ceiling) the directorates/departments

form their zero-based budget input to the Budget Council. The lack of specific guidance to prioritize functions in accordance with the work to be accomplished leaves some doubt as to the method the directorates/departments use to establish their individual functional priorities. Without such guidance, efforts on projects high in the priority of a Directorate may be in conflict with those directed toward completing a project with a high NAVAIRTESTCEN priority.

When all of these inputs are reviewed by the Budget Council, an attempt is made to put all of the decision packages in priority order to determine the distribution of the NAVAIRTESTCON manpower assets. Since only the optimum manning level decision packages are tied to the next fiscal year's workload and the optimum level of a function is not allowed by the published guidance to precede the present level effort in that function, only incremental adjustments to manpower will occur. These adjustments occur only in an upward direction when an optimum level in a function is prioritized ahead of the present level in another function. Decreases cannot occur if all minimum levels must precede the present or optimum levels in the prioritization of decision packages. Obviously, this approach is not realistic in that frequently the work which can be done at the minimum level in one function is not as beneficial to naval aviation as the present or optimum effort levels of another function.

This disjoint, incremental process of manpower allocation cannot be effective until the project priority list has a large influence on the order in which decision packages are prioritized for the entire NAVAIRTESTCON organization.

APPENDIX B

A SATISFICING RESOURCE - ALLOCATION MODEL

The primary elements of all capital budgeting-type models are: benefit function for each project, cost function for each project, and constraints on resources. The model then selects the best portfolio of projects to maximize the benefits within the constraints on total cost.

A. BENEFIT FUNCTION

As described in section II of this thesis,NAVAIRTESTCEN has established a project priority listing which serves as an indication of benefits of a project to the Naval Aviation Program. This listing is updated and published monthly as a guide to the NAVAIRTESTCEN directorates for resource allocation. Although the priority list is dynamic, movement of projects within the list is slow, usually the result of higher priority work being added above the project.

Project priority, although subjective, is fairly accurately estimated by project personnel before being added to the list. In fact, most project priorities cculd be estimated within ± 50 on a scale of one to 500 during the project workload planning for the FAP. Thus, a measure of average yearly benefits versus time for each project could be added to the file. For purposes of developing this model, the author has assigned project priorities to all of the projects in the file.

Because the workload planning data estimates are less reliable as the planning horizon is lengthened, near-term workload should be more heavily weighted than future work in selection of a project portfolio, much the same as discounting cash flows in capital budgeting. At the present time, the rate for discounting NATC projects priority cannot be determined from historical data, but a rate of 20% per annum when applied to priority seems to be a reasonable balance between the uncertainty of the project, and the accuracy with which the estimate can be made of project priority for future years.

Unlike net present value calculations in capital budgeting problems, there is no inherent value to a steady flow of benefits from a project, unless consideration of starting costs in terms of labor is added to the model. For the development of this model, the average of the discounted priorities for all years will be used in the project benefit calculation. Thus,

$$P_j = \frac{\sum_{t^*}^{t^{**}} P_{jt}(1.2)^t}{n},$$

Where t^* is the year in which a project is initiated,

t^{**} is the year in which a project ends,

P_{jt} is the priority of project j in year t, in decending order according to importance, and

n is the number of years in which activity occurs.

In addition to discounting future priorities, it is the author's observation, from having participated in numerous NAVAIRTESTCEN priority meetings and in the competition for resources, that the relative difference in perceived benefits between two projects is a nonlinear inverse relationship to priority. High priority projects (P_j 150) all compete almost evenly for resources, while for low priority projects (P_j 450), the increment in the competition for resources changes dramatically between 450 and 600. For the above reasons the benefit function implemented in the model is given by

$$\Pi_{jt^*} = 1 - \left[\frac{P_{jt^*}}{P_{MAX_t^*}}\right]^2$$

where Π_{jt^*} is the benefit of project j at time t*, and

$P_{MAX_t^*}$ is the maximum priority number at time t*.

The relative benefits of projects with respect to their priority is given in table B-1 for an assumed project load of 600 projects.

TABLE B-1

PROJECT BENEFITS RELATIVE TO PRIORITY

$P_{MAX} = 600$

Average Discounted Project Priority	Benefits
1	1.00
100	0.97
200	0.88
300	0.75
400	0.55
500	0.31

Because there is no file with project priority estimates by fiscal year, it was necessary to use falsified data for checkout of the model for this project. Future use of the model will require the addition of project priority estimates to the NATCWPM file. (This file had 2,504 characters per record during development of the model, but has subsequently been increased to 3,005 characters per record by adding an uncommitted filler at the end of each record. Only 24 characters are required to enter priority numbers for the eight fiscal years.)

B. COST FUNCTION

The oost function for each project is defined as the sum of all the civilian labor from each functional area/cost center (FACC). The costs are defined in man years by year

in which the labor is performed. These data are contained in the NATCWPM master file described in Ref. 14 and Appendix A of this thesis.

The workload planning data for more than 850 projects for the time period FY77 through FY84 were included in the file used for this research. Thirty-five FACC's were identified in which direct project work could be performed. To bound the problem for medium-range workforce planning purposes, only the workload estimates for the current year and four following years are considered in the model. This horizon is compatible with the FYDP manpower planning process and recruiting for long term "Coop" undergraduate training programs -- a source of significant workforce input at NAVAIRTESTCEN.

C. CONSTRAINTS ON RESOURCES

Constraints on asset availability, which in this case are manpower in each FACC, must be included in the model so the optimum portfolio of projects can be selected within the limits of the simple model. To obtain these data, the senior civilian in each NAVAIRTESTCEN directorate was asked to estimate the available direct manpower for each functional area within the manager's cost center. The data of table B-2 resulted from their replies. In the cost center for which no reply was received, manpower equal to workload was entered.

TABLE B-2

CIVILIAN DIRECT LABOR AVAILABLE (Man years)

LACC	FY78	FY79	FY80	FY81	FY82
2AAT	8	8	9	9	10
2BAT	43	45	46	48	49
2CAT	12	12	12	12	12
2DAT	17	17	17	17	17
2ARW	10.5	12	12	12	12
2BRW	13	15	15	15	15
2CRW	5	5	5	5	5
2DRW	3.4	3.4	3.4	3.4	3.4
2ASA	25	25	25	25	25
2BSA	23	23	23	23	23
2CSA	15	15	15	15	15
2DSA	41	41	41	41	41
2ASY	0	0	0	0	0
2BSY	10.1	10.1	10.1	10.1	10.1
2CSY	.8	.8	.8	.8	.8
2DSY	0	0	0	0	0
2ATP	9	9	10	10	10
2BTP	2	2	2	3	3
2CTP	0	0	0	0	0
2DTP	11	11	8	8	8
2ESY	26.2	26.2	26.2	26.2	26.2
2FSY	33.6	33.6	33.6	33.6	33.6
2GSY	24.7	24.7	24.7	24.7	24.7
2HSY	16.1	16.1	16.1	16.1	16.1
2ISY	12.3	12.3	12.3	12.3	12.3
2JSA	26.0	26.0	26.0	26.0	26.0
2KSA	33	33	33	33	33
2LSY	0	0	0	0	0
2MTS	44	41	41	41	41
2NRA	17	17	17	17	17
2OTS	8	10	12	12	12
2PCS	20.8	20.8	20.8	20.8	20.8
2QTS	53	50	51	51	50
2RTC	19	19.5	19.5	19.5	19.5
2SBS	50	50	50	50	50

D. THE SATISFICING MODEL

The elements of a satisficing model have been defined for providing management with an optimum selection of projects within the limited scope of manpower allocations to cost centers. A solution for this problem was developed by Associate Professor G. G. Brown, a faculty member, of the Naval Postgraduate School. The following notation simplifies the explanation of the required mode 1:

Let X_{jt} be (0.1 variable for starting/continuing project j in year t (from model selection process).

a_{ijt} be manyears of labor demanded from FACC i on project j in year t (from NATCWPM).

b_{it} be the constraint on labor from FACC i in year t (from Table B-3).

The model then must satisfy the following:

Maximize $\sum_{jt^*} \Pi_{(X_{jt^*})}$

Subject to $\sum_{j} a_{ijt} X_{jt} \leq b_{it}$ for all i and t

$$X_{j\tau} = X_{jt} \quad \tau = t^* + 1, \ldots, T$$

Where Π is the benefit function

t^* is the year in which project j is initiated

T is the planning horizon of 4 years.

The requirement that X_{jt} take on integer values of zero or one implies that an integer programming algorithm is required. Thus, the model will select a whole project, or reject it, but not permit a solution in which a part of the project is done, as in a linear programming solution. A dynamic programming solution was not considered because the time phasing of the projects is not variable at the NAVAIRTESTCEN level without negotiation with the sponsors.

E. LIMITATIONS

The use of any model by management requires that certain limitations be understood and observed.

1. The model proposed by this thesis chooses only complete projects. If a project is eliminated from the optimum portfolio, it can be simplified in scope, with

alternative data entered as updates to the workload planning data or the priority estimate may be changed. The sensitivity of the portfolio to these management inputs is important to the workforce planning process.

2. The proposed model permits selection of a group of joint or related projects. If one of the joint projects is selected by the model, the others must then be included. Mutually exclusive projects are also permitted, to allow selection of the optimum alternative from several estimates for the same project. Grouping projects by assigning the same priority to all will not assure selection of all the projects.

3. The proposed models choose the optimum portfolio of projects and then indicate the number of excess man years labor left in each. Management must reallocate assets to those FACC's with slack resources (workload in excess of assets) to achieve more of the priority list projects in sequence. A list of eliminated projects can be displayed by the program in numerical sequence according to priority for each year.

4. The model operates on a set of estimates; most of them are probably valid. If high-priority projects are eliminated, either excessively large manpower requirements exist relative to the benefits or a mistake in data entry has occurred.

APPENDIX C

AN OPTIMAL RESOURCE ALLOCATION MODEL

The development of the rationale for the elements making up an optimal resource-allocation model for NAVAIRTESTCEN is described in this appendix. Each element is discussed and quantified to provide the background for subsequent development of the algorithms to solve for the optimal solution.

A. MODEL ELEMENTS

1. Reallocation of Manpower

The reallocation of manpower to accomplish the workload required by the best portfolio of projects requires a model for the costs involved in each transfer. In an attempt to quantify these costs, the senior civilian in each direct cost center at NAVAIRTESTCEN was asked to comment on his perception of the cost to transfer personnel from other FACCs into his organization. This approach was not structured to provide a concensus, in that all possible transfers were not addressed in the survey. The cost of separation was also included in the matrix each manager was asked to complete. The replies were understandably submitted with some reservations on the parts of the managers, who had no historical data available to support their answers.

If no reply was received from the cost center manager, an estimate was put into the matrix based on the author's knowledge of the type work, and the skills, and knowledge required for the work done by the FACC's.

The data for the reallocation costs are summarized in table C-1. A row estimating the cost of hiring and initial training of new employees to achieve productive, direct project work has been included, as has the civilian labor required to contract for and provide monitoring of contractor-supplied labor. A column reflecting the costs associated with separating employees (RIF) has also been included.

The data in table C-1 are the additional man years of civilian labor required to produce one manyear of useful, direct project work. Thus, if a transfer is made from AIR VEHICLES (2A) to A/B INST (2M), 2.2 man years of effort must be assigned for each man year of direct project-related work. If it is necessary to separate some employees to achieve the optimum project portfolio and workforce, the RIF penalty must be included in the selection alternatives.

In a functionally organized activity like NAVAIRTESTCEN, the transfer of personnel is quite costly if the data of table C-1 are approximations of reality. In spite of these costs, it may be desirable to effect moves of personnel into and back out of an FACC in two consecutive years to attain the optimum project portfolio within the total manpower

FROM \ TO FUNCTIONAL AREA	FAP CODE	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2Ø	2P	2Q	2R	RIF
AIR VEHICLE	2A	.3	.8	.3	—	1.5	1.5	.3	1.0	1.0	1.0	1.5	1.5	1.2	1.0	.8	.5	1.0	—	.5
MISSION SYSTEMS	2B	.8	.3	.3	—	.3	.3	.5	.5	1.0	.3	.5	.5	.7	.5	.7	.5	.5	—	.5
REM	2C	.3	.5	.2	—	.7	.5	.5	.3	1.0	1.0	.5	1.0	1.2	1.0	1.0	.8	1.0	—	.5
A/C MAINT	2D	—	—	—	.1	—	—	—	—	—	—	—	—	.4	.5	.5	—	.5	.3	.5
EMV	2E	.5	.3	.5	—	0	.3	.5	.5	1.0	.3	.5	.5	1.0	.8	.6	.8	.6	—	.5
E AND E	2F	.5	.3	.5	—	.3	0	.5	.5	1.0	.5	.5	.5	.8	.6	.5	1.0	.5	—	.5
GSS	2G	.3	.5	.3	—	.8	.8	0	.6	1.0	.7	.8	1.0	1.0	.7	.6	1.0	.6	—	.5
ORDNANCE	2H	.3	.5	.3	—	.7	.5	.5	0	1.0	1.0	.5	1.0	.8	.5	.5	.8	.5	—	.5
CREW SYSTEMS	2I	1.0	1.0	1.0	—	1.0	1.0	1.0	1.0	.0	1.0	1.0	1.0	1.0	.8	.6	.8	.7	—	.5
EW	2J	.5	.3	.4	—	.3	.3	.5	.5	1.0	0	.5	.5	1.0	.5	.7	.8	.8	—	.5
CV SUIT	2K	.3	.5	.5	—	1.5	1.5	.3	1.0	1.0	1.0	0	1.5	1.0	1.0	.5	.5	.5	—	.5
CNI	2L	.5	.3	.5	—	.5	.5	.5	.5	1.0	.5	.5	0	1.0	.6	.7	.8	.6	—	.5
A/B INST	2M	1.5	.5	.5	1.0	1.0	.5	.5	.3	—	1.0	.5	1.0	0	.1	.1	—	.1	—	.5
RANGE	2N	1.5	.5	1.0	—	1.0	.5	.5	.5	—	.5	1.0	.5	.1	0	.1	.3	.1	—	.5
TELEM	2Ø	1.5	.5	1.0	—	1.0	.7	.7	.7	—	.7	1.0	1.0	.1	.1	0	.3	.1	—	.5
COMPUTER	2P	.5	.5	.7	—	1.0	.7	.5	.5	1.0	.5	.7	1.0	1.5	.5	.5	0	.5	—	.5
INST. LAB. SERV.	2Q	1.5	1.5	1.0	1.0	1.0	.7	.5	1.0	—	.7	1.0	1.0	.1	.1	.1	—	0	—	.5
TID	2R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.0	0	.5
NEW HIRE		.5	.5	.3	.1	.5	.3	.3	.3	.5	.5	.5	.5	.3	.3	.3	.3	.3	.3	—
CONTRACTOR		.3	.3	.3	.1	.3	.3	.3	.3	.3	.3	.3	.3	.2	.2	.2	.2	.2	.2	—

NOTE: ESTIMATE OF ADDITIONAL MAN YFARS TO ACHIEVF A ONE MAN YFAR EFFORT FOLLOWING A REALLOCATION OF ASSETS FROM ONE FACC TO ANOTHER.

TABLE C-1
REALLOCATION COST MATRIX
CIVILIAN PERSONNEL

constraints. For this reason, no restriction on personnel movement is included in this model. However, because of the costs involved, most cost centers will operate at levels of efficiency of about 0.76 for one full year before moves will be forced to occur.

Using overtime and withholding or reducing leave authorizations are sources of apparent increased workforce efficiency which have the effect of an increase in labor availability within the same workforce. These mechanism are productive if applied with discretion, and thus should be implemented in the model as another alternative in workforce planning.

Historical data used in project estimating at NAVAIRTESTCEN indicates an average productivity of .85 man years of labor per employee. If only holiday leave were allowed for employees, efficiency could be theoretically increased by 14% without adding to the staff. Additionally, if each employee on the project worked eight hours of overtime per week, the increased efficiency would amount to .37 man years per person. Thus, the model should allow for project workload assignment up to 137% of the labor availability constraint of a functional area during any year.

Continuation of this policy over long periods of time may be harmful to morale and is in conflict with DOD policy to avoid overtime work whenever practical. For these reasons,

the use of overtime and restricted leave are limited in the model to periods of one year.

2. Contractor Manpower

In many instances, the NATCWPM data base contains estimates of contractor manpower to provide unique capabilities for a project. The cost of this manpower has been included in the workload planning data as part of the total project cost. For these reasons, the model should not reduce contractor labor required below the estimated level.

Increases in contractor manpower as a substitute for civilian labor can be useful in achieving the required work-force structure for a project. However, there are some limitations imposed by the nature of the workload at NAVAIRTESTCEN. In the support directorates, contractor personnel cannot be added to a level at which safety and evaluation of test results become jeopardized. For purposes of developing the background for this reallocation model, the civilian personnel level in support directorates must be maintained at not less than 30% of the total assigned workforce in the FACC. The following FACC's are included in the support area:

(1)	A/B INST	(2M)
(2)	RANGE	(2N)
(3)	TELEM	(2O)
(4)	COMPUTER	(2P)
(5)	INST LAB SERV	(2Q)
(6)	TID	(2R)
(7)	BASE SUP	(2S)

All other FACC's can utilize contractor manpower to varying degrees, depending on the nature of the projects. Evaluation and reporting of test results, critical limits testing, and measurement of contract-guarantee performance must be performed by employees of the Navy or other government agencies. For those T & E FACC's in which the substitution or addition of contractor personnel is desirable in attaining the optimum set of projects, a minimum of 50% of the workforce must be civilian or military as determined by the model, with the exception of maintenance, A/C MAIN (2C) and (2T), which may be permitted to go to 0% civilian and 15% military.

The limitations on the contractor workforce are derived from comments submitted by various cost center managers at NAVAIRTESTCEN, and the lowest ratio of contractor support to civilian and military labor in the workload planning data file NATCWPM.

In addition to the manpower costs already indicated in table C-1, the cost of adding contractor personnel to a project must be evaluated by the model in the optimal decision process. For purposes of this model, it will be assumed that total labor cost increases of 20% may be incurred by any project if the cost increase occurs in years one through four of the project. Estimated cost increases in the budget and planning years can be transmitted to the sponsor to assure adequate funding is provided for project execution. Increases in year zero should not be permitted, since NAVAIRTESTCEN will already be committed to performing that work within the sponsor's budget.

Labor costs for civilian labor in all FACC are assigned a value of $25,000 per man year, with an 8% compound growth for the time period to the planning horizon of four years.

Contractor labor for functional area 2D (Aircraft Maintenance) is assigned a cost of $30,000 per man year; all other contractor-supplied labor is assumed to cost $70,000 per man year. Compounded annual growth of contractor costs is estimated at 10% per annum.

3. Military Manpower Requirements

Flight hours required by projects have a large effect on the maintenance manpower requirements of each of the flying directorates. The maintenance manpower requirements are frequently underestimated by project personnel

when filling out the workload planning data worksheets for inclusion in the NATCWPM file. Because military manpower is a constrained resource, it is important that the impact of flight hour requirements be included in the evaluation of projects by the model.

The total military manpower requirements of NATC are generally greater than the allowances in each of the directorates. The direct workload requirements include officer and enlisted personnel involved in direct project work, in addition to maintenance officers and personnel directly associated with maintaining the inventory of aircraft. Constraints on military manpower by FACC are shown in table C-2. Differentiation between officer and enlisted manpower is not included in the tabulation, nor is any differentiation included in the model. However, the assignment of military personnel to T & E functional areas is predominantly officers, while enlisted personnel make up the largest percentage of the population in the maintenance and support FACC's.

4. <u>Aircraft Resources</u>

Aircraft assets within the Navy Research, Development Test and Evaluation (RDT&E) organizations are held at the lowest possible inventory level, due to the demands for these assets by the fleet and because of the high value of the aircraft inventory. The number of aircraft at NAVAIRTESTCEN

TABLE C-2

MILITARY DIRECT LABOR AVAILABLE

(Man/years)

FACC	FY78	FY79	FY80	FY81	FY82
2AAT	7	7	7	7	7
2BAT	8	8	8	8	8
2CAT	3	3	3	3	3
2DAT	70	70	70	70	70
2ARW	4	4	4	4	4
2BRW	4	4	4	4	4
2CRW	1.5	1.5	1.5	1.5	1.5
2DRW	30	30	30	30	30
2ASA	10	10	10	10	10
2BSA	7	7	7	7	7
2CSA	7	7	7	7	7
2DSA	190	190	190	190	190
2ASY	0	0	0	0	0
2BSY	2	2	2	2	2
2CSY	0	0	0	0	0
2DSY	0	0	0	0	0
2ATP	14	14	14	14	14
2BTP	3	3	3	3	3
2CTP	0	0	0	0	0
2DTP	71	51	21	13	13
2ESY	0	0	0	0	0
2FSY	0	0	0	0	0
2GSY	2	2	2	2	2
2HSY	7	7	7	7	7
2ISY	5	5	5	5	5
2JSY	5	5	5	5	5
2KSA	5	5	5	5	5
2LSY	0	0	0	0	0
2MTS	0	0	0	0	0
2NRA	0	0	0	0	0
2OTS	0	0	0	0	0
2PCS	0	0	0	0	0
2QTS	0	0	0	0	0
2RTC	22	19	19	19	19
2SBS	30	30	30	30	30

is a soft constraint in that if project load demands more assets, they generally are assigned to the inventory (but the justification must be well founded). By including the aircraft assets as an unconstrained commodity, shortages (and surpluses) in aircraft types can be identified by the model for planning purposes.

The aircraft utilization parameter of interest in terms of project accomplishment is the number of flight hours per year. Historically, certain types of aircraft can only be flown a limited number of hours per aircraft per year. Thus, the number of aircraft required is a function of total project flight hours required in that aircraft type.

Table C-3 presents data for flight hours per aircraft per year and maintenance labor requirements estimate for most NAVAIRTESTCEN RDT&D aircraft types. From these data, unconstrained aircraft requirements for the project portfolio, and an estimate of maintenance labor requirements can be calculated.

Due to management decisions during the reorganization of NAVAIRTESTCEN in 1975, military manpower for aircraft maintenance has been supplemented with a large contingent of contractor labor in some cost centers. This trend is expected to continue as one of the cost centers moves to an all contractor maintenance force, except for the safety related and monitoring function. Whether the model would reinforce this decision is unknown, but provisions for

the factors which must be considered should be included in the model definition.

Because the cost of military manpower is not considered to be a direct project expense at NAVAIRTESTCEN (except in a statistical sense), a management decision was made to distribute the labor costs of all civilian and contractor maintenance personnel to the projects as if all labor costs were equal. There is no penalty to a cost center having a disproportionate share of civilian or contractor labor. However, there is a perceived difference in skill level and efficiency between the three maintenance labor categories. The labor requirements estimates in the workload planning data and the maintenance man years per 100 flight hours of table C-3 assume an efficiency factor of 100% for military personnel in the maintenance sub cost centers. If civilian labor is substituted, an efficiency of 110% will be applied by the model. The substitution of contractor labor for military labor will result in an increase in efficiency to 125%, which will reduce the calculated or estimated labor assigned to aircraft maintenance.

The preceding paragraphs describe a basis for treating the change in type of labor within the maintenance labor requirements. However, accounting for all of the maintenance labor required is a more critical problem in the model due to the data base of the NATCWPM file. Estimates of labor

TABLE C-3

MAINTENANCE LABOR REQUIRED AND FLIGHT HOUR YIELD
(FUNCTIONAL AREA = 2D)

TYPE A/C	MAX FLT HRS/YR/A/C (Estimated)	FACC	MMY/100 FLT HRS)
A3	250	2DSA	1.29
A4	500	2DSA	.76
A6	350	2DSA	2.21
A7	300	2DSA	1.36
AV8	250	2DSA	2.03
A18	350	2DSA	1.08*
C1	350	2DAT	.73*
C2	250	2DAT	.90*
C130	500	2DAT	.96
E2	250	2DAT	1.56
F4	250	2DSA	2.20
F14	300	2DSA	2.80
F18	350	2DSA	1.08*
H1	400	2DRW	.65
H2	300	2DRW	1.35
H3	200	2DRW	1.17
H46	200	2DTP	.95
H47	200	2DRW	1.23*
H53	200	2DRW	1.28
H58	600	2DTP	.59*
H60	300	2DRW	1.08*
P3	600	2DAT	.97
S3	400	2DAT	1.42
T2	400	2DTP	.54
TA4	600	2DTP	.76
TA7	300	2DSA	1.36
T33	300	2DSA	1.25*
T34	600	2DSA	.50*
T38	400	2DTP	1.03*
T39	600	2DAT	.59*
T44	600	2DAT	.78*
OV1	300	2DTP	.85
OV10	300	2DSA	.74
U1	300	2DTP	.82
U6	300	2DTP	.82
X26	250	2DTP	.55

*Estimated

required for aircraft maintenance in the data base file are frequently not adequate to support the flight hours estimated by the project engineer or officer. The data in table C-3 permit calculation of military manpower requirements for maintenance based on the flight hour requirements. If the labor requirements for a project, which are calculated by multiplying maintenance manhours per 100 flight hours from table C-3 by the required project flight hours from the NATCWPM record, are greater than the estimated labor in the NATCWPM record, the calculated value should be substituted as the maintenance labor requirement for the project. The substitution of labor types should also be based on the labor requirements calculated in this manner.

As discussed in Appendix B, contractor personnel estimates by project should not be reduced by the model. These requirements have been included to gain specific skills and knowledges required for timely completion of the project.

5. Improvement and Modernization Requirements

Many NAVAIRTESTCEN projects require an investment of capital in new facilities or equipment before their objectives can be met. This investment comes from a constrained source of institutional I & M funds under element RDT&E 65864N. Adding this constrained resource to

the model is another improvement in understanding and accounting for the impact of the variety of quantifiable environmental factors.

Table C-4 lists the NAVAIRTESTCEN IMP's, with the estimated funding profile required to meet the schedules of various RDT&E projects.

The workload planning data NATCWPM file contains data which define the IMP(s) required by a project for successful completion. In the project selection process, the model must assure that I & M funding is available for the associated IMP and the schedules of the project and IMP are compatible before the project is selected. Once an IMP has been "turned on" by selection of a direct project, other projects will share the facilities. I&M projects which cannot be funded within the constraints of the total IMP Budget for each year should be listed by the model so that improved justification can be provided to higher authority for planning purposes.

6. Other Model Elements

Civilian labor cost and benefit functions for projects are the same as for the satisficing model described previously, in Appendix B. Thus, the data from tables B-1, B-2, and B-3 are part of the implementation of this model.

TABLE C-4

NAVAIRTESTCEN

IMPROVEMENT AND MODERNIZATION
PROJECT (IMP) REQUIREMENTS ($1000)

	Fiscal Year			
IMP	79	80	81	82
A-1	490	810	840	915
A-2	1076	500	500	500
A-3	265	600	490	600
A-4	500	550	150	--
A-5,6	--	1000	400	1800
A-7	--	400	800	--
A-10	490	386	314	320
A-13	300	75	--	--
A-14	25	435	330	--
B-1	--	938	1110	1130
B-2	77	5	10	20
B-3	165	115	125	155
C-1	60	--	--	--
C-2	218	85	285	285
C-3	100	100	100	100
C-4	142	--	--	--
C-5	174	84	84	78
C-6	35	28	15	45
D-1	--	50	50	50
D-2	89	90	90	90
E-1	--	26	26	26
E-3	--	29	29	10
E-3	--	20	10	10
E-4	--	25	25	--
E-5	--	25	25	--
F-1	--	5200	5400	5500
F-2,2A	--	160	111	82
F-3	--	470	--	--

	Fiscal Year			
IMP	79	80	81	82
F-4	--	--	168	168
F-5	--	25	278	65
F-6	--	60	74	--
F-7	10	10	10	--
F-8	--	50	100	100
F-9	50	75	50	--
F-10	--	90	90	90
G-2	--	--	--	--
G-5	--	84	--	--
G-6	--	82	--	--
G-7	--	40	40	40
G-9	--	304	--	--
G-10, H-1, I-7, J-1	382	1815	1750	945
G-12	--	161	--	--
H-2	200	100	100	50
H-3	61	100	25	25
I-2	--	254	900	360
I-3	165	233	490	315
I-4	--	90	40	10
I-5	--	165	820	50
I-6	125	65	50	20
I-8	--	68	58	60
I-9	153	121	132	68
I-10	--	170	84	24
I-12	--	80	40	15
I-13	--	310	160	115
J-3	--	125	200	25
J-4	--	200	100	--
Constraint	4000	7400	10100	11500

The benefit function for this allocation model should be expanded to improve the utility of the model. However, no additional explicit or quantifiable implicit factors were discovered during the research.

B. THE REALLOCATION MODEL

The quantifiable elements which impact on the solution for an optimum portfolio of projects have been described in the previous sections of this appendix. The mathematical operations of the model are described in terms of the following notation:

Let: X_{jt} be (1,0) variable for starting/continuing project j in year t (from model selection process).

a_{ikt} be manyears of labor demand from $FACC_j$ on project j in year t (from NATCWPM).

b_{ikt} be constraint on labor type k from $FACC_i$ in year t from (Tables 3-2 and 3-4 and constraints on contractor labor costs).

c_{iklt} be immediate annual cost of assigning labor type k from $FACC_i$ to $FACC_l$ in year t (from table 3-3 and contract labor costs).

y_{iklt} be number of man years of effort assigned of labor type k from $FACC_i$ to $FACC_l$ in year t (calculated in model).

d_{mjt} be units of resource m consumed by project j in year t (from tables 3-5 and 3-6).

D_{mt} be total availability of resource m in year t (tables 3-5 and 3-6).

t^* be the year in which a project begins.

π be the benefit function(from Appendix B).

α_{iklt} be efficiency of workers assigned of labor type k from $FACC_i$ to $FACC_l$ in year t.

γ A scaling constant

$$\alpha_{iklt} = \epsilon_k \left[\frac{1}{1+C_{iklt}} \right]$$

where: ϵ_k

Military	1.0
Civilian	1.1
Contractor	1.25
Civilian(O.T.)=	1.375

A model proposed by Associated Professor G. G. Brown to produce the optimal solution for the allocation model is given by:

$$\text{MAXIMIZE:} \quad \sum_{jt^*} \Pi(x_{jt^*}) - \gamma \sum_{iklt} c_{iklt} y_{iklt}$$

$$\text{Subject to:} \quad \sum_{j} d_{mjt} x_{jt} \leq D_{mt} \quad \text{over all m and t}$$

$$\sum_{k,l} \alpha_{iklt} y_{iklt} - \sum_{j} a_{ijt} x_{jt} \geq 0 \quad \text{over all i and t}$$

$$\sum_{l} y_{iklt} \leq b_{ikt} \quad \text{over all i, k and t}$$

$$x_{j\tau} = x_{jt^*} \quad \tau = t^*+1, \ldots, T$$

Other constraints enforcing, for instance, mutual exclusion of two equivalent alternate project plans

$$(x_{jt^*} - x_{j't^*} = 0)$$

Because of the magnitude of the implementation effort, (estimated at 1,000 man-hours) and the programming skill and knowledge required, the development of the program to solve the model was not accomplished as part of this thesis research. The development of such a program would give NAVAIRTESTCEN management the high resolution insight for major revisions in the workforce, which could then accomplish a maximum amount of the most beneficial workload.

The total NAVAIRTESTCEN direct project labor demand in FY79 exceeds 1,400 manyears, according to the data in the NAVAIRTESTCEN workload plan management file. Thus, the saving of only one percent on labor by improving the manpower resource allocation is significantly greater than the cost of developing such a program. A number of limitations to the use of this model were given previously as limitations on using the simpler satisficing model.

REFERENCES

1. Office of The Chief of Naval Operations, OP-923G, Historical Budget Data, 9 March 1978.

2. Steiner, George A., and Miner, John B. Management Policy and Strategy, p 1-270, MacMillan Publishing Co., Inc., 1977.

3. Commander, Naval Air Systems Command Letter 6103T/BB to Distribution List, Subject: Navy T&E Consolidated Long Range Plan of the Major Range and Test Facility Base (MRTFB) Activities (February 1978), 20 March 1978.

4. Planning Your Staffing Needs, Bureau of Policies and Standards, United States Civil Service Commission, 1977.

5. Etzion:, Amatai, "Mixed Scanning: A "Third" Approach to Decision Making," Public Administration Review, p. 385-392, December 1967.

6. Weingartner, H. Martin, "Capital Budgeting of Interrelated Projects; Survey and Synthesis," Management Science, Vol. 12, No. 7, p. 485-516, March 1966.

7. Harvey, Allan, "Factors Making for Implementation and Failure," Management Science, Vol. 16, No. 6, p. B-312 - B-321, February 1970.

8. Enthoven, Alain C., "Analysis, Judgement and Computers," Business Horizons, August 1969.

9. COMNAVAIRSYSCOM msg. 142105Z, September 1976.

10. COMNAVAIRSYSCOM msg. 231538Z, August 1976.

11. Instruction Booklet, Workload Plan Management System, Naval Air Test Center.

12. Commander, Naval Air Test Center Letter 3900 Ser CT85/78 to Commander, Naval Air Systems Command (AIR-06). Subject: The Effect of Lack of Personnel Resources on Project Completion, 10 February 1978.

13. Commander, Naval Air Systems Command Letter 620/GEW to Commander,Naval Air Test Center, Subject: AIRTASK Priority Classification, 13 March 1978.

14. Van Bellen, L.W., NATC Workload Plan Management System--Program Specification -- Financial Details, Unpublished Notes, Naval Air Test Center, 25 August 1977.

BIBLIOGRAPHY

A. MANPOWER MANAGEMENT

1. Blood, Jerome W., The Management of Scientific Talent, p. 30-36, 99-112, 195-198, American Management Association, 1963.

2. Research Analysis Corporation, RAC-R-141, Integrated Manpower Programming Phase 1 Study (IMP-1) by Duane S. Cason and Thomas R. Cross, April 1972.

3. U.S. Civil Service Commission, Planning Your Staffing Needs, 1977.

4. Naval Postgraduate School, Report Number NPS55Eg75061, Systems Analysis and the Dynamics of Manpower, June 1975.

B. POLICY AND STRATEGY

1. Ayres, Robert U., Technological Forecasting and Long-Range Planning, p. 160-202, McGraw-Hill, 1969.

2. Miller, Ernest C., Advanced Techniques for Strategic Planning, p. 5-60, American Management Association, 1971.

3. Steiner, George A., Strategic Factors in Business Success, p. 1-26, Financial Executives Research Foundation, 1969.

C. DECISION MAKING AND PROBLEM SOLVING

1. Davis, Gary A., Psychology of Problem Solving, p. 1-39, Basic Books, Inc., 1973.

2. Easton, Allan, Complex Managerial Decisions Involving Multiple Objectives, p. 2-31, 54-98, John Wiley & Sons, Inc., 1973.

3. Greenberger, Martin, Crenson, Matthew A., and Crisseg, Brian L., Models in the Policy Process, p. 23-46, Russel Sage Foundation, 1976.

4. Janis, Irving L., and Mann, Leon, Decision Making, p. 1-41, The Free Press, 1977.

5. Simon, Herbert A., The New Science of Management Decision, p. 1-136, Prentice-Hall, Inc., 1977.

D. RESOURCE ALLOCATION

1. Boness, A. James, Capital Budgeting, p. 1-41, 68-100. Praeger Publishers, 1972.

2. Bower, Joseph L., Managing the Resource Allocation Process, p. 1-82, Graduate School of Business, Harvard University, 1970.

3. Cetron, Marvin J., and Others. Technical Resource Management Quantitative Methods, The Massachusetts Institute of Technology, 1969.

4. Lombaers, H. J. M., and Others. Project Planning by Network Analysis, p. 268-273, North-Holland Publishing Co., 1969.

5. Martino, R. L., Project Management and Control, Vol.II, p. 110-132, American Management Association, 1964.

6. Woolsey, Robert E. D. and Swanson, Huntington S., Operations Research for Immediate Application, A Quick and Dirty Manual, p. 65-76, Harper & Row, 1969.

7. Carney, Thomas P., An Optimization Model for Investigating Alternative Research and Development Program of the U.S. Army, M.S. Thesis, Naval Postgraduate School, Monterey, 1971.

8. Baker, N.R., and Others, "A Budget Allocation Model for Large Hierarchical R&D Organizations, Vol. 23, No., p. 59-70, Sept. 1976.

E. MISCELLANEOUS

1. Naval Postgraduate School, Civilian Personnel Handbook, by LCDR John R. Anderson and Others, p. 1-16 -- 1-27.

2. Sackman, Harold, Delphi Critique, p. 1-11, 35-43, 57-70, Lexington Books, 1975.

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